

The Hardy-Weinberg Theorem and Teddy Grahams

Introduction

Charles Darwin's unique contribution to biology was not that he "discovered evolution" but, rather, that he proposed a mechanism for evolutionary change—**natural selection**, the differential survival and reproduction of individuals in a population. In *On the Origin of Species*, published in 1859,

Darwin described natural selection and provided abundant evidence in support of **evolution**, the change in populations over time. However, at the turn of the century, geneticists and naturalists still disagreed about the role of selection and the importance of small variations in natural populations. How could these variations provide a selective advantage that would result in evolutionary change? Ayala (1982) defines evolution as "*changes in the genetic constitution of populations*." A **population** is defined as a group of organisms of the same species that occur in the same area and interbreed or share a common **gene pool**, all the alleles at all gene loci of all individuals in the population. The population is considered to be the basic unit of evolution. Populations evolve, not individuals.

In 1908, English mathematician **G. H. Hardy** and German physician **W. Weinberg** independently developed models of population genetics that showed that the process of heredity by itself did not affect the genetic structure of a population. The **Hardy-Weinberg theorem** states that the frequency of alleles in the population will remain the same regardless of the starting frequencies. Furthermore, the equilibrium genotypic frequencies will be established after one generation of random mating. In this scheme, if **A** and **a** are alleles for a particular gene locus and each diploid individual has two such loci, then **p** can be designated as the frequency of the **A** allele and **q** as the frequency of the **a** allele. Thus, in a population of 100 individuals (each with two loci) in which 40% of the alleles are **A**, **p** would be 0.40. The rest of the alleles (60%) would be **a**, and **q** would equal 0.60 (i.e., $p + q = 1.0$). These are referred to as **allele frequencies**. The frequency of the possible diploid combinations of these alleles (**AA**, **Aa**, **aa**) is expressed as $p^2 + 2pq + q^2 = 1$.

This theorem is valid only if certain conditions are met:

1. **The population is very large.** (The effect of chance on changes in allele frequencies is hereby greatly reduced).
2. **Matings are random.** (Individuals show no mating preference for a particular phenotype) **There are no net changes in the gene pool due to mutation, that is, mutation from A to a must be equal to mutation from a to A.**
3. **There is no migration of individuals into and out of the population.**
4. **There is no selection; all genotypes are equal in reproductive success.**

NATURAL SELECTION IN TEDDY GRAHAMS.

*You are a bear eating monster. There are two kinds of bears that you like to eat: happy bears and sad bears. You can tell the difference between them by the way they hold their hands. Happy bears hold their hands high in the air, and sad bears hold their hands down low. Happy bears taste sweet and are easy to catch. Sad bears taste bitter, are devious and hard to catch. Because of this **you only eat happy bears**. The happy trait in bears is caused by the expression of a recessive allele. The homozygous recessive condition being happy. The sad trait is caused by a dominant allele. New bears are born every year (when they are hibernating in their den [cardboard box]) and the birth rate is **one** new bear for every old bear left from the last year.*

Scientific Question: Is the population of Teddy Grahams in Hardy-Weinberg equilibrium?

Hypothesis: Write a hypothesis to answer the questions.

Procedure:

1. Obtain a population of 10 bears and record the number of happy and the total population number.
2. Using the equations for Hardy-Weinberg equilibrium, calculate the frequencies of both the dominant and recessive alleles and the genotypes that are represented in the population. (happy is recessive , q^2)
Ex. If 5 of the 10 bears are happy, then 10 out of 20 alleles would be happy alleles.
Therefore the q^2 number would be .5.
3. **Now, go hunting!** Eat 3 happy bears. (If you do not have 3 happy bears then eat the difference in sad bears)
4. Once you have consumed the bears, obtain a new generation from your den (the box). You should only remove 7 additional bears from the den for a total of 14 bears.
5. Repeat the procedures again, be sure to record the number of each type of bear, the total population, and calculate the allele and the genotype frequencies.
6. Repeat procedure for a third generation.

Data:

Generation	Happy	Total	q^2 (happy)	p^2 (sad)	$2pq$ (sad)	p	q
1.		10					
2.		14					
3.		22					

Data Analysis:

1. Describe what is happening to the genotype and allele frequencies in the population of Teddy Grahams?
2. What would you expect to happen if you continued the selection process for additional generations?
3. How would the frequencies change if you were to now select for the sad bears?
4. Why doesn't the recessive allele disappear from the population? How is it protected?

Conclusion:

Write a conclusion based on your data to answer the question: Is the population of Teddy Grahams in Hardy-Weinberg equilibrium?